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Loss Assessment of Eastern Dwarf Mistletoe A Survey Technique

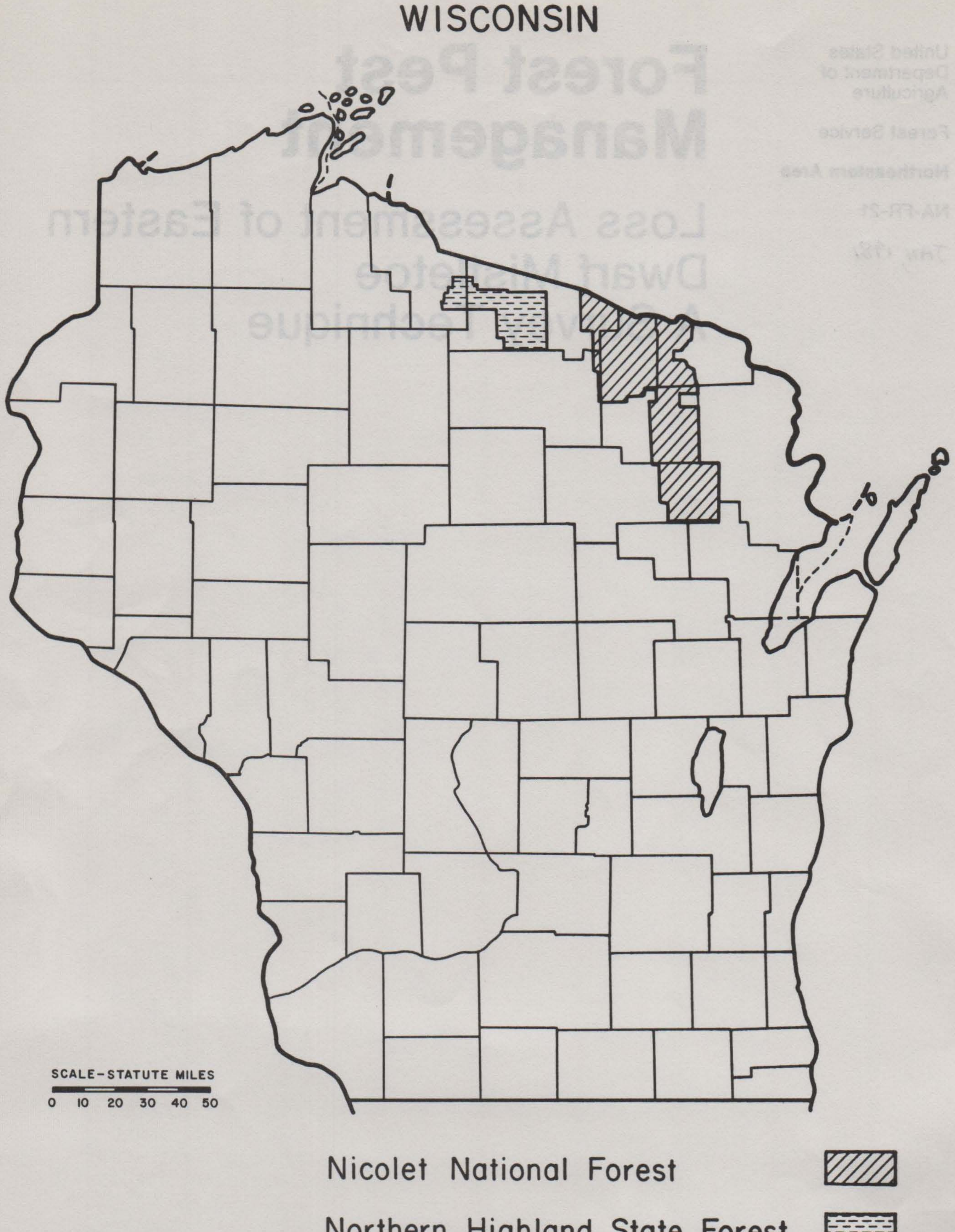

Figure 1.--Nicolet National Forest and Northern Highland State Forest, Wisconsin.

INTRODUCTION

Eastern dwarf mistletoe (Arceuthobium pusillum Peck) is the most damaging disease of black spruce (Picea mariana (Mill.) B.S.P.) in the Lake States. Anderson (1949) estimated that 10 percent of the 2.2 million acres of commercial black spruce type was infested with this parasitic plant. A 1976 survey of black spruce on Lake States National Forests showed that 15 percent of 291,000 acres surveyed contained dwarf mistletoe (Anderson and Mosher 1977). Although the disease occasionally occurs on white spruce (P. glauca (Moench) Voss) and tamarack (Larix laricina (Du Roi) K. Koch), its primary host in the Lake States is black spruce.

Although distribution information for eastern dwarf mistletoe is available (Anderson 1949, Anderson and Mosher 1977), timber volume loss caused by the disease has not been measured over a large area. Growth loss data are usually obtained by measuring radial increment over a time period or comparing tree size of infected and non-infected trees. Ground surveys are particularly time-consuming and expensive due to the inaccessibility of Lake States black spruce stands. It may be more efficient to measure timber volume loss using aerial photography.

Aerial photography has been used to detect dwarf mistletoe infection centers in black spruce (French et al. 1975, Meyer and French 1966). Pockets of mistletoe-killed trees are evident on aerial photographs of infested stands, but no relationship has been established between mortality center characteristics and volume loss. If such a relationship exists, aerial photography could be useful for quantifying mistletoe-caused timber volume loss.

OBJECTIVE

The objective of this pilot survey was to evaluate an aerial photography sampling system for measuring timber volume loss caused by eastern dwarf mistletoe in northern Wisconsin.

METHODS

The project was done in black spruce stands on the Nicolet National Forest and the Northern Highland State Forest, Wisconsin (Figure 1). Timber volume loss was measured in stands having various intensities of dwarf mistletoe infestation (non-infested to heavy infestation). The evaluation consisted of three phases:

1. Sample selection and identification
   The location and acreage of commercial black spruce stands was determined from resource photography and compartment examination data. Only black spruce stands larger than 10 acres were evaluated. Forty-two stands were identified on the two Forests: 26 on the Nicolet and 16 on the Northern Highland. Initially, all identified stands were used in the pilot survey.

2. <u>Aerial photography and photo interpretation.</u>
Two sets of aerial photographs, using scales of 1/4000 and 1/8000, were taken of each sample stand during September, 1979. Photographs were taken with color infrared film (type 2443) and a Wratten 12 filter, using a 9 x 9 inch format. Photography was done by Aero-Metric Engineering, Inc. of Sheboygan, Wisconsin[1/]. Photo interpretation was done at the Forest Insect and Disease Management laboratory in St. Paul, Minnesota.

An Old Delft stereoscope set at 4.5 power on a light table was used for photo interpretation. Stand boundaries were outlined on each photograph for both scales. Potential dwarf mistletoe infection centers were outlined on the photo transparencies. An area/density rating was calculated for each infection center using the following formula:

R = A x D where: R = area/density rating
A = area of infection center (in acres)
D = density rating of infection center (i.e., rating of 1-4)
- 1 = <25% of area with live trees
- 2 = 25 to 50% of area with live trees
- 3 = 51 to 75% of area with live trees
- 4 = >75% of area with live trees

3. <u>Ground check</u>
All accessible potential infection centers identified on the 1/8000 scale photographs were ground checked to determine dwarf mistletoe presence. A variable radius plot (BAF=10) was arbitrarily located in each infection center and in a non-infested part of the stand near the suspected infection center. Data collected on each plot included d.b.h., condition class and number of four foot bolts per tree (i.e. only for trees $\geq$ 5 inches d.b.h. to a 3 inch top). Tree condition classes were:
- 1 = live black spruce, no mistletoe
- 2 = live black spruce, mistletoe-infected
- 3 = dead black spruce, mistletoe-infected
- 4 = dead black spruce, no mistletoe
- 5 = live, other tree species
- 6 = dead, other tree species

[1/] The use of trade or company names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U. S. Dept. of Agriculture of any product to the exclusion of others that may be suitable.

Presence of witches brooms and dwarf mistletoe shoots or basal cups were used to diagnose infected trees.

The area/density rating derived from photo interpretation was compared with on-the-ground conditions and discrepancies were noted. The age and height of three dominant black spruce trees per stand were recorded for site index calculations.

RESULTS & DISCUSSION

Three of the 42 stands photographed were eliminated from the survey during photo interpretation because two had no tree mortality and one was not black spruce. The 39 remaining stands had 73 mortality centers identified on the photographs. During field checking, 21 additional stands were eliminated because of poor access or absence of black spruce type. Eighteen stands, with 39 mortality centers, were ground checked.

The total area of the 18 stands was 549 acres. Although we only intended to survey stands larger than 10 acres, several of the ground checked stands were smaller than our established minimum. Stand size ranged from 5 to 67 acres and averaged 29 acres. Site index ranged from 28 to 50 with an average of 41. Mean d.b.h. (i.e. 5.4 inches) did not differ on healthy vs affected plots. During the ground check, the area density rating (ADR) system was eliminated because time did not permit validation by ground survey acreage measurements.

Primary mortality factors were:

Mortality factor	No. stands affected *	No. mortality centers affected	Acres affected	Percent of total acres surveyed
Dwarf Mistletoe	13	27	36	6.5
Windthrow	5	5	3	.6
Flooding	4	4	7	1.2
Unknown	2	3	2	.3

*More than one mortality factor occurred in some stands.

Average basal area and volume calculations were made for affected vs healthy plots (Table 1).

Mortality centers were relatively easy to identify on the photos and interpretation time averaged about 12 minutes per center. Acreage estimates for the centers were more difficult to calculate on the 1/8000 scale photos than on the 1/4000 photos, but the smaller scale transparencies were easier to use in the field. The 1/4000 scale photos had some image distortion around the edges, however, mortality center boundaries or limits were easier to define. Dwarf mistletoe infection centers were correctly identified 27 out of 39 times (69 percent). The ground checking experience gained during the survey would help substantially reduce the error of commission in subsequent photo interpretation. No mistletoe infection centers that had not been identified on the photos were detected during the ground survey. Thus, we were not able to identify any errors of omission.

Difficulty in timing the ground survey necessitated modifications of the original work plan. Photo interpretation of the 1/4000 scale photos could not be completed before starting the ground check survey. Thus, only the 1/8000 scale photos were used for ground checking. The inaccessibility of black spruce stands, and the difficulties of traveling to and through them, caused several problems. The best time to travel in black spruce bogs is early winter, before deep snow hinders travel, but after bogs begin to freeze. Some stands could not be checked because of deep water and mud, even though hip boots were worn.

No growth loss and defect measurements were taken, so timber volume losses are based only on dead or dying tree volumes. Basal area calculations were made to better represent unmerchantable trees killed by dwarf mistletoe. Numerous mistletoe-killed trees just under merchantable size were found. There was no apparent relationship between the occurrence or severity of dwarf mistletoe and site index. Site index in mistletoe-infested stands ranged from 28 to 50 with an average of 40.

Eleven percent of the mean total volume on affected plots was killed by dwarf mistletoe, but 20 percent of the basal area had been killed. Differences in basal area and volume for condition classes 1, 2, and 3 in healthy vs affected plots were quite large (Table 1). On affected plots, 46 percent of the volume and 55 percent of the basal area was either infected with dwarf mistletoe or had been killed by it. Since most mistletoe-infected trees will eventually die from the disease, 5.8 cords per acre will be lost in infection centers. In addition, 3.0 cords per acre of black spruce and other tree species were killed by other agents. In total, 8.8 of 12.5 cords per acre (70 percent) were dead or dying in contrast to 0.9 cord per acre on the healthy plots. For the 549 acres sampled, dwarf mistletoe caused an average volume loss of 0.5 cord per acre.

Total basal area and volume differences on healthy vs affected plots may be attributed to two primary factors; reduction in the growth rate of heavily-infected trees and past tree mortality. Although these factors were not measured in this survey, we observed numerous fallen and deteriorating mistletoe-killed trees.

Windthrow and flooding were the other primary mortality factors identified during the survey. Both occurred with similar frequency, but twice as much area was affected by flooding. Field observations indicated that flooding, usually caused by beaver dams, was more extensive than our data indicated. Some stands were not ground checked because high water blocked access. On the photos, these stands often had relatively large areas of dead trees that appeared to be killed by flooding.

The purpose of this pilot survey was to test a sampling system, rather than to evaluate the importance of dwarf mistletoe. However, survey results provided some significant information regarding potential losses from the disease. Through stratification of the ground check data, average basal area and volume calculations were made for dwarf mistletoe infected vs healthy plots (Table 2). In dwarf mistletoe-infested stands, an average of 9.7 percent (range = 0.8 to 39.6 percent) of the stand area was affected.

When only mistletoe-infected plots were considered, 18 percent of the total volume was killed by the disease and 56 percent was living but infected (Table 2). Since mistletoe eventually kills most infected trees, the total loss amounts to 74 percent (8.3 cords per acre) of the volume and 81 percent of the basal area. In addition, 0.8 cord per acre of black spruce and other species died from other causes. Thus 9.1 cords per acre, out of 11.2 (81 percent), were dead or dying. There were almost no living, non-infected black spruce on the mistletoe-infected plots. In contrast, only 0.9 cord per acre was dead or dying on the healthy plots. It should be noted that the total volume loss from dwarf mistletoe still averaged 0.5 cord per acre over the 549 acres sampled.

When mistletoe-infected and healthy plots were compared, there was essentially no difference between volumes for condition classes 4, 5, and 6. Unlike windthrow and flooding, mistletoe was species specific and had almost eliminated black spruce from the infection centers. The difference in mean total volume on healthy vs infected plots was larger than when all mortality factors were considered (Table 1 vs Table 2). This result may confirm the observation that mistletoe-caused growth reduction and past mortality account for the difference in total volume on the plots.

CONCLUSIONS

The aerial photography sampling system, using 9 x 9 inch color infrared transparencies at a 1/8000 scale, was an effective method of locating dwarf mistletoe infection centers in accessible black spruce stands. However, poor access precluded ground verification of photo interpretation results in over 50 percent of the photographed stands. Ground checking affected stands provided information on stand condition, stand structure and timber volume. The photographic record provided by this survey system was easy to use for field checking and will provide a permanent record of disease center location and approximate size. Land managers wishing to treat mistletoe infection centers can use survey results to set control priorities and establish treatment area boundaries.

Dwarf mistletoe infection centers were correctly identified on photos 69 percent of the time in accessible stands. Through the experience we gained during this survey, the error of commission could be reduced in future surveys. Commision errors were associated with windthrow and flooding mortality centers. Flooding was the most important of the two, but affected only one-fifth as many acres as dwarf mistletoe.

Dwarf mistletoe caused significant volume loss in infection centers and will eventually eliminate black spruce from most centers. Average volume loss caused by dwarf mistletoe was 0.5 cord per acre in the 549 acres surveyed.

RECOMMENDATIONS

1. An aerial photography sampling system using 9 x 9 inch color infrared transparencies at a 1/8000 scale can be used to locate dwarf mistletoe infection centers in black spruce stands.
2. Accessibility to sample stands should be determined, as much as possible, prior to ground checking.
3. Accessible mortality centers should be ground checked by point sampling with 10 BAF plots. The number of centers to be checked and number of plots needed will depend on accessibility, precision desired and size of the mortality centers.
4. Ground check data should include measurements of site index, d.b.h., merchantable volume, and tree condition class. The area density rating system is not recommended for this type of survey.
5. Growth of healthy and dwarf mistletoe-infected trees should be measured by sampling 10-year radial increment.
6. Timber volume loss caused by eastern dwarf mistletoe should be determined for commercial black spruce stands in Minnesota. Since most of the Lake States commercial black spruce occurs in Minnesota, Wisconsin and Michigan need not be surveyed.

ACKNOWLEDGEMENTS

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Table 1.--Average basal area (BA) and volume on 39 affected and 39 healthy ground check plots. Affected plots include all mortality factors observed.

	CONDITION CLASS *						
	1	2	3	4	5	6	Total
Affected Plot BA							
(ft^2/acre)	13.1	42.6	23.9	20.8	15.6	4.4	120.4
(% of total)	11	35	20	17	13	4	100
Healthy Plot BA							
(ft^2/acre)	106.2	1.3	0	9.2	18.7	2.1	137.5
(% of total)	77	1	0	7	14	2	101**
Affected Plot Volume							
(cds/acre)	1.5	4.4	1.4	2.4	2.2	.6	12.5
(% of total)	12	35	11	19	18	5	100
Healthy Plot Volume							
(cds/acre)	12.2	.2	0	.6	2.5	.1	15.6
(% of total)	78	1	0	4	16	1	100

* Condition Classes:
1 = live black spruce, no mistletoe
2 = live black spruce, mistletoe-infected
3 = dead black spruce, mistletoe-infected
4 = dead black spruce, no mistletoe
5 = live, other tree species
6 = dead, other tree species

** Rounding error results in more than 100 percent

Table 2.--Average basal area (BA) and volume on 27 Dwarf mistletoe affected and 27 healthy ground check plots. Infected plots include only those infected with dwarf mistletoe.

	Condition Class *						
	1	2	3	4	5	6	Total
Infected Plot BA							
(ft^2/acre)	1.5	61.5	34.4	5.9	12.2	1.9	117.4
(% of total)	1	52	29	5	10	2	99**
Healthy Plot BA							
(ft^2/acre)	108.5	1.9	0	9.6	18.2	2.2	140.4
(% of total)	77	1	0	7	13	2	100
Infected Plot Volume							
(cds/acre)	.1	6.3	2.0	.6	2.0	.2	11.2
(% of total)	1	56	18	5	18	2	100
Healthy Plot Volume							
(cds/acre)	13.0	.2	0	.6	2.3	.1	16.2
(% of total)	80	1	0	4	14	1	100

* Condition Classes: 1 = live black spruce, no mistletoe
2 = live black spruce, mistletoe-infected
3 = dead black spruce, mistletoe-infected
4 = dead black spruce, no mistletoe
5 = live, other tree species
6 = dead, other tree species

** Rounding error results in less than 100 percent